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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : G01S 5/00 — A1

(11) International Publication Number: **WO 00/39602**

(43) International Publication Date: 6 July 2000 (06.07.00)

(21) International Application Number: PCT/US99/26889

(22) International Filing Date: 10 November 1999 (10.11.99)

(30) Priority Data:
09/221,899 28 December 1998 (28.12.98) US

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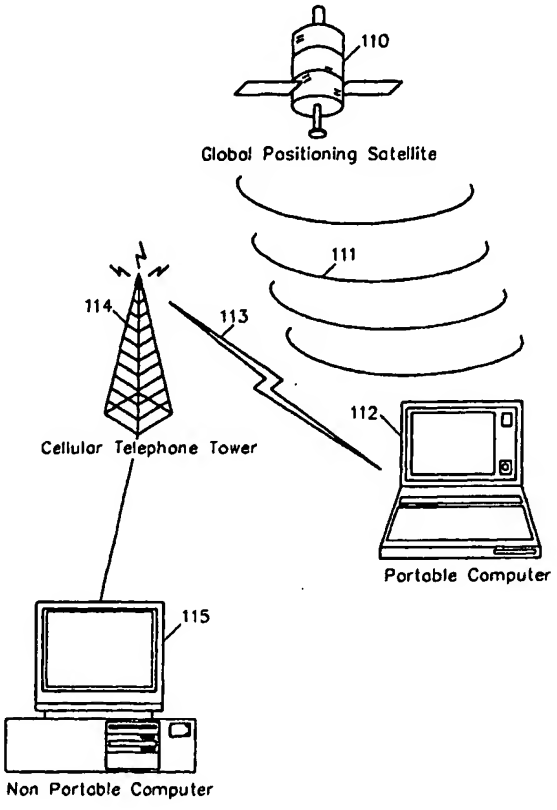
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: PORTABLE COMPUTER LOCATING DEVICE

(57) Abstract

A location device and system is disclosed for tracking the location of a computer. A tracking apparatus is activated either manually or by failure to execute an authorization. Once activated, a geographic locator such as a global positioning unit periodically determines geographic coordinates corresponding to the location of the computer. Data comprising the geographic coordinates of the portable computer (112) can be logged in a storage medium along with a time stamp indicating the time of day and day of year of the geographic determination. In addition data describing geographic location and other information can be transmitted to a preprogrammed destination, thereby remotely tracking the location of the computer.



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PORTABLE COMPUTER LOCATING DEVICE

BACKGROUND OF THE INVENTION

This invention relates generally to a locating device for a portable computer. In particular this invention relates to a locating device for a computer that comprises a geographic location device and a transmitter that will transmit the location of the computer.

The physical size as well as the electrical and sometimes cooling connections involved in the installation of early computers often acted as a primary deterrent to the theft or misplacement of a computing unit. However, the proliferation of powerful computers that are portable in size and require minimal hookups has led to an increase in loss through theft and misplacement of units. Due to the significant reduction in size and consequent portability of computers, there has developed a popular practice of carrying a computer for use during travel. Businesspersons as well as academics, government personnel and private individuals, have made computers an almost indispensible tool relating to every type of endeavor. They have found it convenient to be able to carry a computer set up with files and equipment useful to their particular needs.

The proliferation of portable computers outfitted with valuable equipment and files has increased the exposure resultant to loss of the computer. Loss may occur through human error or through theft. The expense of replacing a computer can be substantial. This is especially so when a computer is fully loaded with licensed software and peripherals such as modems, CD players, multimedia, network boards and other specialized equipment. However, the cost of a computer may be of minimal concern in relation to the tactical exposure related to losing data contained within a computer.

In today's information era, data and knowledge are easily equated with value. The value of data contained on a single computer can be enormous. This makes it imperative that a computer not be permanently misplaced or stolen. In addition it becomes even more important not to let a computer containing sensitive data become available to a competitor, or in the case of national security matters, to a foreign agent.

Numerous known security devices are designed to prevent the theft of a computer. A number of these devices physically restrain the computer to a large or otherwise immovable object. This type of protection is useful for a computer that is meant to remain in one location. A variation on this technique is to physically secure a computer to the person of someone transporting the unit. This may be effective but for obvious reasons it is also inconvenient. Other devices sound an alarm if a computer passes outside of an authorized area such as a building or a compound. This provides some greater latitude, but still requires that a computer remain at one geographic location.

To protect data, it has also been known to physically remove a data storage media, such as a hard drive, from a computer while the computer is in transport. The media is physically smaller and less easily targeted than an entire computer and therefore more easily protected. However, the disassembly of a computer is inconvenient and it requires some degree of skill to remove and restore the media without damaging the computer or media. Additionally, if an independent media is misplaced or stolen, it is more difficult to identify and recover. It is useful, therefore, to have a system that can locate a misplaced or stolen computer. A preferred means of locating a computer system is to have the system transmit a geographic location indicating the computer's whereabouts.

One method of determining a geographic location as shown in FIG. 1 is by use of the Global Positioning System. Global Positioning System (GPS) technology is known to be used for locating vehicles; it is particularly well known for use on air and marine vehicles. The United States government has placed a series of satellites into orbit, each satellite 27 transmits a signal that allows a user below to compute a latitude and longitude coordinate. It is common for vehicles to use GPS to determine a current location as well as the speed and direction of travel.

The global positioning system consists of a man-made constellation having 24 satellites orbiting approximately 11,000 miles from the earth and continuously broadcasting their identity and location via electromagnetic signals. These signals are encoded with the time they are transmitted from the satellite 27. Therefore, by subtracting the encoded transmission time from the time of reception by a GPS receiver, the propagation time delay between transmission and reception of the signals can be determined. Relative position of the GPS receiver can then be derived by knowing the

propagation time delay and the speed at which the electromagnetic waves travel through the atmosphere.

Position via GPS can also be determined via satellite 27 position data encoded in an electromagnetic signal. Satellite 27 position data is updated only once an hour by the GPS satellite 27. By simple geometry, specifically triangulation, the location of a GPS receiver can be determined. The use of triangulation to determine location is well known and has been used to determine global position from such objects as stars or terrestrial objects. The more satellite 27 signals acquired by a GPS receiver, the more accurate location information will be. Tracking devices utilizing GPS technology offer advantages over systems using other means as hereto foreknown. GPS technology is operational in any weather. Another advantage in using GPS is that it is available worldwide, 24 hours a day, 365 days a year.

An alternate way to electronically determine geographic location utilizes a LORAN transmitting network to provide raw data used with a known triangulation computation technique for positively indicating the position of a receiver. Generally speaking, a typical LORAN system includes a master transmitting station and at least four slave transmitters. The master station transmits a coded series of pulses used to synchronize the operation of the slave transmitters. After a predetermined coding delay, each slave transmitter will transmit coded pulses. A LORAN receiver placed at a location receives both the signals transmitted by the master as well as the signal transmitted by slave transmitter. Since the exact latitude and longitude coordinates of each of these stations is known, the time delays between the transmission by the slave transmitter and receipt of these signals by the receiver are used.

Using LORAN and standard triangulation techniques, latitude and longitude coordinates can be determined. One problem encountered by LORAN transmitters occurs because they transmit a ground wave of relatively low frequency between 90 and 110 kilohertz, the accuracy of this system is compromised because the signal is affected by the terrain over which it travels.

It has been taught to combine various security systems with GPS. One personal security system combines a global positioning system navigation unit with the substantially worldwide communication capabilities of a cellular telephone or

communication satellite 27. A mobile unit communicates emergency data including position coordinates to a central dispatch station that receives the emergency data and accurately displays necessary information superimposed on a digitized map indicating a position corresponding to a location transmitted from a mobile unit. Such a device that can be worn or carried by a user and activated in an emergency situation is useful for locating missing persons such as a downed pilot or a remote hiker.

Still another approach teaches an apparatus that monitors a vehicle with respect to predefined geographical boundaries. If a person or vehicle travels outside of a predefined geographic boundary, an alarm is activated and a geographic location along with other information is transmitted from the vehicle to an authorized station.

Predefined geographic boundaries can be useful for tracking fleet vehicles but are not appropriate for a portable computer for which it is difficult to predefine authorized geographic areas. Therefore, it useful to have a system to track the geographic location of a computer without physical limitations and transmit the tracking information to a predetermined receiver.

SUMMARY OF THE INVENTION

Accordingly, a location device and system are disclosed for tracking the location of a computer. A tracking apparatus is activated either manually or by failure to execute an authorization code. Once activated, the tracking apparatus causes a geographic locator such as a global positioning unit periodically to determine geographic coordinates corresponding to the location of the computer. Data comprising the geographic coordinates of the portable computer 112 can be logged in a storage medium 210 along with a time stamp indicating the time of day and day of year of the geographic determination. In addition this invention teaches that data describing geographic location and other information can be transmitted to a preprogrammed destination, thereby remotely tracking the location of the computer.

In one embodiment a user will activate a computer locating apparatus located internally to a computer 112 upon commencement of travelling. Until deactivated, the locating apparatus will periodically determine a geographic location and store information relating to the location of the computer in a storage medium internal to the

computer. Periodically, the apparatus will also cause the computer to transmit the location information and other stored information such as an identity of the computer and a time stamp to a receiver. The receiver is an electronic device capable of receiving information from a particular transmission used to transmit the data. The receiver can also store the geographic data and time stamp sent by a portable computing unit.

In another embodiment the apparatus can become activated upon startup of a computer in the event a required authorization is not entered. During startup a screen can be presented prompting for an authorization code thereby reminding a user to input an authorization code to disable the computer tracking device. Alternatively, a blank screen or a screen depicting a graphical image with no prompt can also be displayed. An authorized user will know that a particular screen image indicates the computer is waiting for an authorization code to be entered. If the code is not entered, the geographic tracking system is activated. To a non-authorized user a blank screen or a screen displaying a benign looking image will appear to be part of a normal boot sequence and not raise suspicions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of a computer tracking system according to this invention.

FIG. 2 is a block illustration of a computer with the geographic location device and transmitter attached.

FIG. 3 is a flow diagram showing an information path during use of this invention.

FIG. 4 is a flow diagram illustrating a transmission medium availability check.

FIG. 5 is a flow diagram illustrating a modem transmission process.

FIG. 6 is an illustration of a portable computer comprising a transmission antenna and concealed GPS unit.

DETAILED DESCRIPTION OF THE INVENTION

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings which form a part hereof and in which is shown by way of illustration of a specific embodiment in which the invention may be practiced. This embodiment is described with sufficient detail to enable those skilled in the art to

practice the invention, and it is understood that other embodiments may be utilized whereby structural or logical changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense and the scope of the present invention is defined by the appended claims.

Referring now to FIG. 1, a tracking system illustrating a preferred embodiment of this invention is shown. A portable computer 112 including a geographic location device 212 receives global positioning data 111 from a global positioning system (GPS) satellite 110 and periodically stores the GPS data in a storage 210. GPS data can be used to calculate latitude and longitude values thereby describing a precise geographic location of the computer.

Latitude and longitude determination is made using triangulation. A triangulation calculation can be executed by a GPS device connected to a portable computer, or raw GPS data can be stored for later use. For example a portable computer 112 may transmit 113 accumulated raw GPS data to an electronic receiving device at a remote location 115. The electronic receiving device, or some other processor logically connected to the electronic receiving device, can then calculate latitude and longitude designations using triangulation. In addition GPS data can be stored in the GPS device, in the portable computer or in an electronic receiving device receiving the GPS data via transmission.

Other embodiments comprise electronic methods for determining a geographic location other than the global positioning system. A system such as the LORAN system can also provide necessary location data. A LORAN receiver receives signals from LORAN transmitters. The signals contain data that can be utilized to determine a latitude and longitude designation. Received LORAN data can be used in calculations and stored in a fashion similar to GPS data. In addition this invention is meant to include other electronic systems that become available for providing geographic designation.

It is preferred that a time stamp be added to geographic location data. A time stamp can be added by a GPS unit, a portable computer or a receiving device. The time stamp associates a time of day and a day of the year with geographic data. It is preferable that a time stamp reflects the time that geographic positioning data is received by a portable computer.

It is most useful to have continuous data indicating when a portable computer was at a particular location, and for the duration of time that the portable computer remained at that location. Data comprising GPS or LORAN data, time stamp and device identification can be referred to as location data. Location data can also comprise a latitude and longitude designation with a time stamp and device identification.

Referring now again to FIG. 1, a transmission 113 is illustrated originating from a portable computer 112. A transmission 113 can proceed through an intermediary receiver such as a cellular telephone tower 114 to a receiving device such as a non-portable computer 115. An intermediary receiver facilitates the receipt of a transmission by the receiving device. Transmissions can be accomplished for example via a cellular telephone resident in the portable computer. A cellular call is periodically placed to the receiving device. The receiving device is programmed or otherwise set up so that it is compatible to receive electronic data transmitted by the portable computer.

By default, transmissions can be conducted with no audio or visual indicators signifying that a transmission is taking place. This surreptitious approach is preferred so that a tracking system can operate undetected by an unauthorized possessor of the portable computer. An option for enabling audio and visual indicators can be built into the tracking system to override the default. If indicators are put in place, it is preferable to be able to turn the indicators on or off.

In one embodiment a portable computer 112 can be programmed to periodically attempt transmissions on a predetermined time schedule. A predetermined time schedule can reflect a pattern useful to a user of this invention. For instance a portable computer 112 may attempt transmission 113 every 5 minutes, or it may seek to transmit every hour, and in the event the transmission 113 is not successful, attempt transmission every 90 seconds until a successful broadcast is completed. Once completed, the schedule can be reset to transmit again one hour from a successful transmission.

Another embodiment specifies transmission 113 in response to predetermined criteria such as time periods least likely to have human observation. Even with no visible or audio indicators of a transmission 113 taking place, a careful observer may notice disk activity, or a line busy due to an attempted transmission 113. To lessen the probability of

being observed, a transmission 113 may for example be programmed to take place during late night or early morning hours.

Still another embodiment specifying predetermined criteria comprises transmission 113 that is attempted after some time interval has elapsed from a last keystroke or other portable computer 112 operator action. A delay from a last operator action may indicate that there is no operator sufficiently close by to observe a transmission 113. This feature would operate similar to a screen saver that constantly checks for a last input from a keyboard, mouse or other input device 216 associated with the computer 112. If a predetermined time elapses, a routine executes, in this case a software routine effectuates the transmission of location data.

Transmission mediums can include for example, radio broadcast, modem, or internet communication. The computer 112 can be programmed to constantly attempt transmissions of various medium types. As a transmission medium becomes available, the portable computer can then send accumulated data via that medium to a receiver.

With reference to Fig. 4, a process 400 is shown for broadcast to a receiver such as a police monitor or to a private receiver. A poll can be conducted for an available broadcast medium, such as radio 111. Radio broadcast can be made in the high frequency range or low frequency range made available for private use. A limitation on radio transmission is the finite distance that a radio transmission can travel. This requires that a radio receiver be relatively close to a transmitting computer. However, the beneficial aspects of a radio broadcast include the ability to be a continuous repetition of a very short burst of data. Repetition increases the likelihood that the transmission 113 will get through to a receiver. In addition a radio transmission will give little or no indication that it is taking place.

A modem transmission 412 of geographic data can take place if a portable PC is connected to a phone line subsequent to the storage of geographic location data. For modem transfer, it is preferable that a file containing accumulated geographic location data be compiled. As modem transfer becomes available, the portable computer would effectuate a transfer of the accumulated geographic location data 415 without user intervention. Software controlling the modem transmission can cue off of a polling signal to the modem.

With reference to Fig. 5, this polling signal would check for modem presence 511. If the presence of a modem is detected, availability of the modem 512 is checked. Finally, a test for the presence of a dial tone is executed 513. If a poll indicates that a modem and dial tone are available, then the software can implement a call and cause the data file to be transmitted 415.

Using a similar testing routine a computer 112 can check for availability to network communication such as the internet communication 413. A portable computer 112 can test for the presence of a predetermined destination and if the test is successful, geographic location data can be transferred to the predetermined destination. For example a ping can be sent to a particular IP address via an internet access device such as a modem or a network board. If the ping reaches the IP address then a transfer of accumulated data 415 can take place to the IP address. This technique can be particularly useful if an unauthorized operator connects a portable computer being tracked to the internet.

A receiving device 115 can receive and display location information transmitted by a portable computer 112. In a preferred embodiment the receiving device 115 can be a second computer, such as a non portable computer. The receiving device 115 can store the received geographic data for future reference. Data can be stored according to the device identification thereby enabling the receiving device 115 to compile a chronology of times and locations of the portable computer 112.

One embodiment comprises a receiving device 115 that sends a notification of receipt of geographic location data to a predetermined destination. For example a designated administrator may receive notification. It is particularly desirable to notify a designated administrator when geographic data is received from a portable computer as a result of unauthorized use of the portable computer 112. Notification can be accomplished locally to the receiving device by way of visual screens and audio alarms. In addition a receiving device can place a telephone call with an audio or pager message, send e-mail, send a fax or use other available electronic communications.

The geographic location system can be installed as an integral part of the portable computer. During operation computer software code stored in memory 210 is executed by the processor 213. The memory 210 comprising RAM 214 and at least one hard drive

215 is electrically connected to the processor 213. The processor 213 operative with the software code causes a geographic location device 212 that is also electrically connected to the processor 213, to receive positioning data from an external geographic reference such as a GPS satellite 110. The geographic location device 212 will typically receive the positioning data and calculate latitude and longitude values based on the positioning data received. The executed code will cause the latitude and longitude value to be stored in memory 10. In the alternative positioning data can also be stored in memory 210. In one embodiment a portable computer 112 time stamps geographic location data and combines it with a device identification to create location data. The location data is then transmitted by a transmission device 211 via a transmission antenna 221. The transmission device 211 is also electrically connected to the processor 213.

Software execution can commence at the option of a user of the software whereby geographic data will be gathered until the software is terminated. Software execution can also commence as a result of an unauthorized use of the portable computer 112. Unauthorized use can be determined through use of an authorization code. At start up a startup screen can act as a cue to input an authorization code. If the authorization code is not input during a designated period of time then the software causing the location tracking can commence. The start up screen does not need to indicate that an authorization code should be input.

A disarming mechanism can be used to terminate execution of software. Disarming can be in response for example to a power on sequence, a combination of keystrokes, a manual switch or other user interactive device.

Initial setup and execution of the computer code can be accomplished through the use of an input device 216 such as a keyboard or a pointing device associated with the portable computer 112. Access to the computer code can be secured with a password or other security device that prevents the code from unauthorized display on a display unit 217 utilized by the portable computer 112.

Circuitry comprising a GPS unit or other geographic location device can be concealed within the portable computer 112. A geographic location device 212 can be incorporated into a main circuitry board of the portable computer 112, or concealed beneath a keyboard. One embodiment disguises a unit comprising a geographic location

device 212 as an optional hard drive 215 or floppy drive 218. By packaging a geographic location device 212 as a drive unit, power and data channels are conveniently made available to the geographic location device 212 and the presence of the device remains unobvious.

Other embodiments can include a geographic location device 212 externally secured to the portable computer 112. This type of unit will be obvious to an unauthorized operator. However, the obvious presence of the unit may deter an unauthorized operator from misappropriating a portable computer 112 so equipped.

Antenna for receiving 220 and transmitting 221 can also be incorporated into a portable computer 112. Antenna such as a transmitting antenna 221 can be concealed within a display casing 40 (FIG. 6). A vertical display casing 40 provides a convenient method of providing for an upright antenna. In addition a single antenna can be used as a transmitting and receiving antenna.

A portable computer 112 can also be programmed to verify that an installed geographic location device 212 has not been tampered with. Tampering can be determined by electronic test routines. If the routines fail, tampering is indicated. In the event of tampering, the portable computer 112 can execute a predetermined response. Responses may include encryption of the hard drive or other disabling of the computer.

Power for the geographic location device 212 and transmission device 211 can be supplied by the power source 231 for an associated portable computer 112 or via an independent power source 230. For convenience it is preferred that the power source 231 for the portable computer 112 be utilized for general use. However, it is also useful to incorporate an independent power source 230 such as a backup battery for use only by the geographic location device 212 and transmission device 211. An independent power source 230 can provide power to the geographic location device 212 and transmitter 211 in the event that operation of the portable computer 112 drains a primary power source for the portable computer 112. It is useful if an independent power source 230 is electrically connected to a portable computer power source such that it will be charged during a normal charging cycle of the portable computer power source 112.

Those skilled in the art will recognize that the method and apparatus of the present invention has many applications, and that the present invention is not limited to

the representative examples disclosed herein. Moreover, the scope of the present invention covers conventionally known variations and modifications to the system components described herein.

CLAIMS

What is claimed is:

1. A locating device for a computer comprising:

   a computer including a processor and a memory electrically connected to the processor, at least a portion of said memory for storing computer software;

   an electronic geographic location device electrically connected to the processor;

   a transmitter electrically connected to the processor; and

   a computer software program stored in the memory and controlling the processor;

   the processor operative with the program to:

      receive geographic location data from the electronic geographic location device; and

      cause the transmitter to transmit the geographic location data.

2. The locating device of claim 1 wherein the processor is additionally operative to store the geographic location data in a computer storage medium.
3. The locating device of claim 1 wherein all stored geographic location data is transmitted.
4. The locating device of claim 1 wherein the processor is additionally operative to time stamp the geographic location data thereby causing the time stamp to be transmitted or stored with the geographic data.
5. The locating device of claim 1 wherein the geographic location device receives geographic location data from the global positioning system.
6. The locating device of claim 1 wherein the geographic location device receives geographic location data from a LORAN system.
7. The locating device of claim 1 wherein the processor operative with the program determines latitude and longitude designations from the geographic data.
8. The locating device of claim 1 wherein the geographic location device calculates a latitude and longitude designation.
9. The locating device of claim 1 wherein the transmitter comprises an antenna.
10. The locating device of claim 9 wherein the antenna is concealed within the display casing.

11. The device of claim 1 wherein the computer additionally comprises an input device and a display.
12. The locating device of claim 1 wherein the processor is additionally operative to add a device identification to the geographic location data thereby causing the device identification to be transmitted or stored with the geographic data.
13. The locating device of claim 1 additionally comprising a disarming mechanism.
14. The locating device of claim 13 wherein the disarming mechanism comprises software code operative with the processor to cease transmission and storage of geographic location data.
15. The locating device of claim 1 wherein the transmitter transmits on a predetermined schedule.
16. The locating device of claim 1 wherein the transmitter transmits in response to predetermined criteria.
17. The locating device of claim 1 wherein the transmitter is selected from the group consisting of a cellular phone unit, a radio transmitter, a modem, and an internet access device.
18. The locating device of claim 1 wherein the processor becomes operative in response to tampering test routines.
19. The locating device of claim 1 additionally comprising an independent power source.
20. A system for tracking the location of a computer comprising:

    a computer including a processor and a memory electrically connected to the processor, at least a portion of said memory for storing computer software code;

    an electronic geographic location device electrically connected to the processor;

    a transmitter electrically connected to the processor; and

    a computer software program stored in the memory and controlling the processor;

    the processor operative with the program to:

        receive geographic location data from the electronic geographic location device and cause the transmitter to transmit the geographic location data; and

    an electronic receiver device to receive the transmitted geographic location data.

21. The system of claim 20 additionally comprising an intermediary receiver to facilitate the transmission of the geographic location data.
22. The system of claim 20 wherein the transmitter is selected from the group consisting of a cellular phone unit, a radio transmitter, a modem, and an internet access device.
23. The system of claim 20 wherein the electronic receiving device displays the geographic location data.
24. The system of claim 20 wherein the electronic receiving device stores the geographic location data.
25. The system of claim 20 wherein the electronic receiving device sends a notification of receipt of the geographic location data to a predetermined designation.
26. A method of tracking the location of a computer having a computer memory, the method comprising:

    electronically determining the geographic location of the computer using an electronic geographic location device;

    storing the geographic location as geographic location data in the computer memory; and

    transmitting the geographic location data stored in the computer memory to an electronic receiving device.
27. The method of claim 26 further comprising time stamping the geographic location data.
28. The method of claim 26 further comprising displaying the geographic location data on the receiving device.
29. The method of claim 26 further comprising storing the geographic location data in the electronic receiving device.
30. The method of claim 26 further comprising identifying the geographic location data with a computer identification.

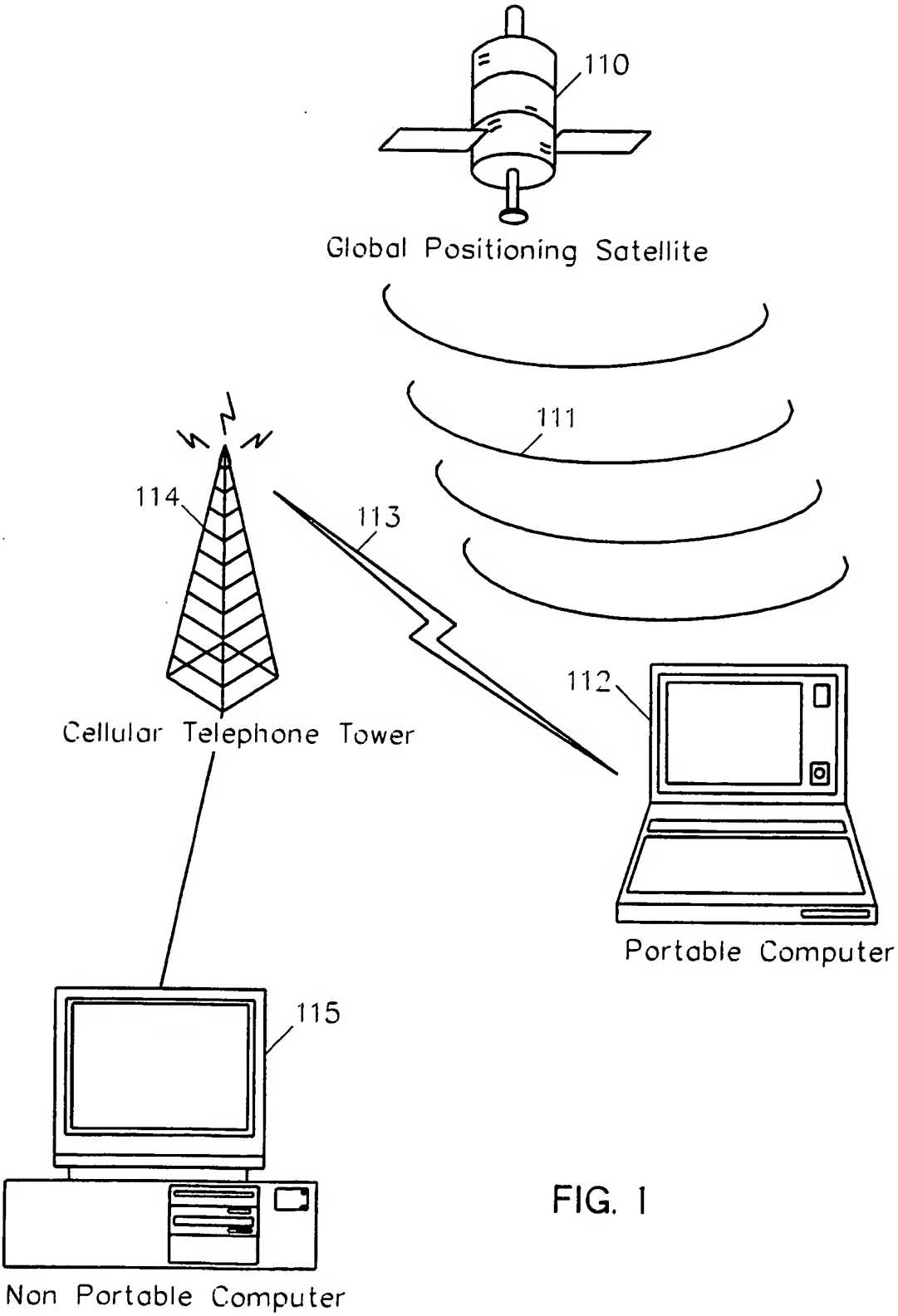
110
Global Positioning Satellite
111
114
113
112
Cellular Telephone Tower
Portable Computer
115
Non Portable Computer

FIG. 1

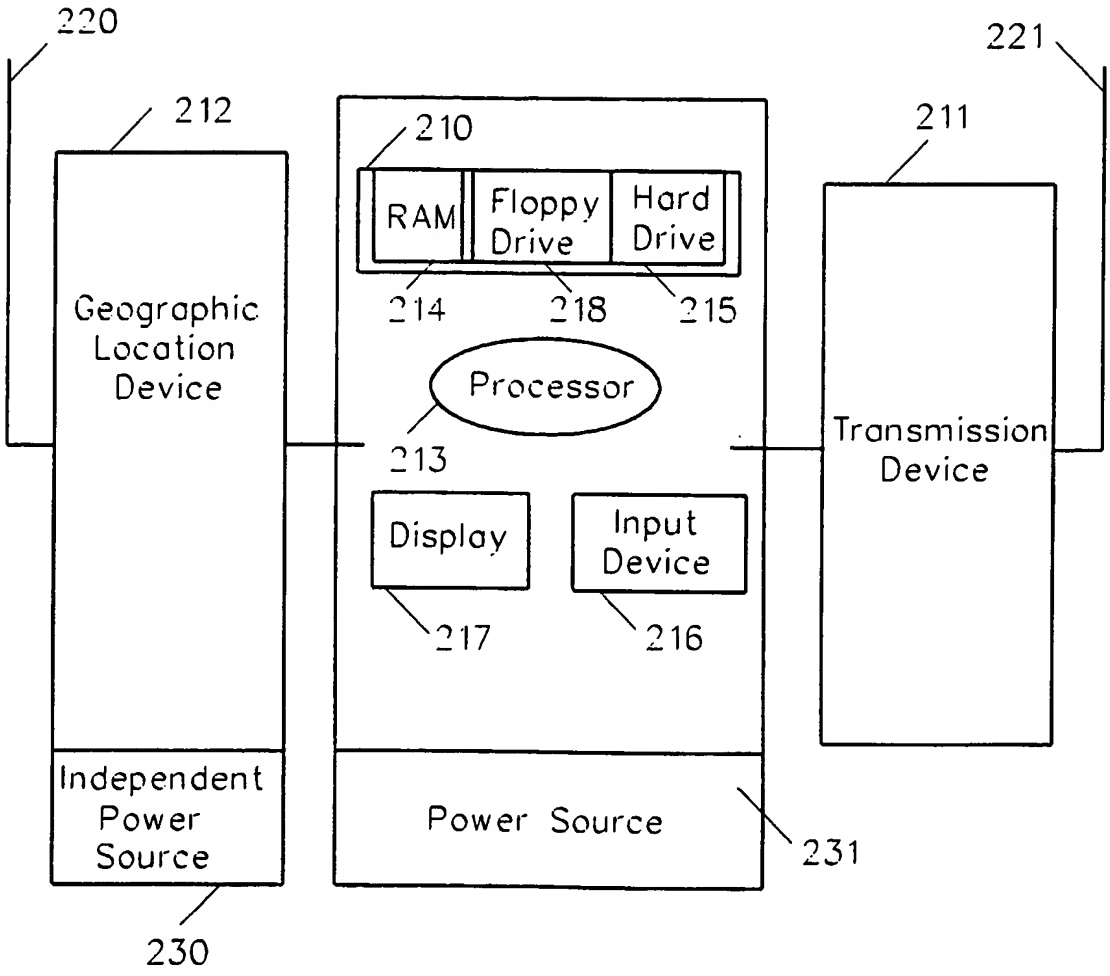
220
221
212
210
211
RAM
Floppy Drive
Hard Drive
214
218
215
Geographic Location Device
Processor
213
Transmission Device
Display
Input Device
217
216
Independent Power Source
Power Source
231
230

FIG. 2

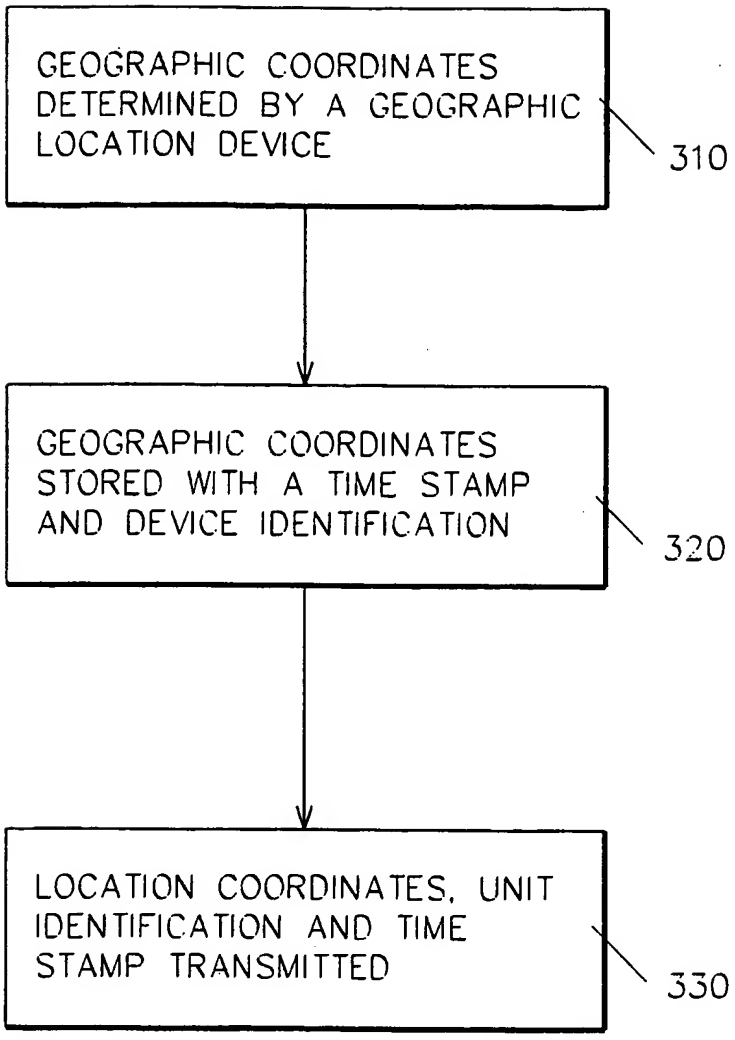
GEOGRAPHIC COORDINATES DETERMINED BY A GEOGRAPHIC LOCATION DEVICE
310
GEOGRAPHIC COORDINATES STORED WITH A TIME STAMP AND DEVICE IDENTIFICATION
320
LOCATION COORDINATES, UNIT IDENTIFICATION AND TIME STAMP TRANSMITTED
330

FIG. 3

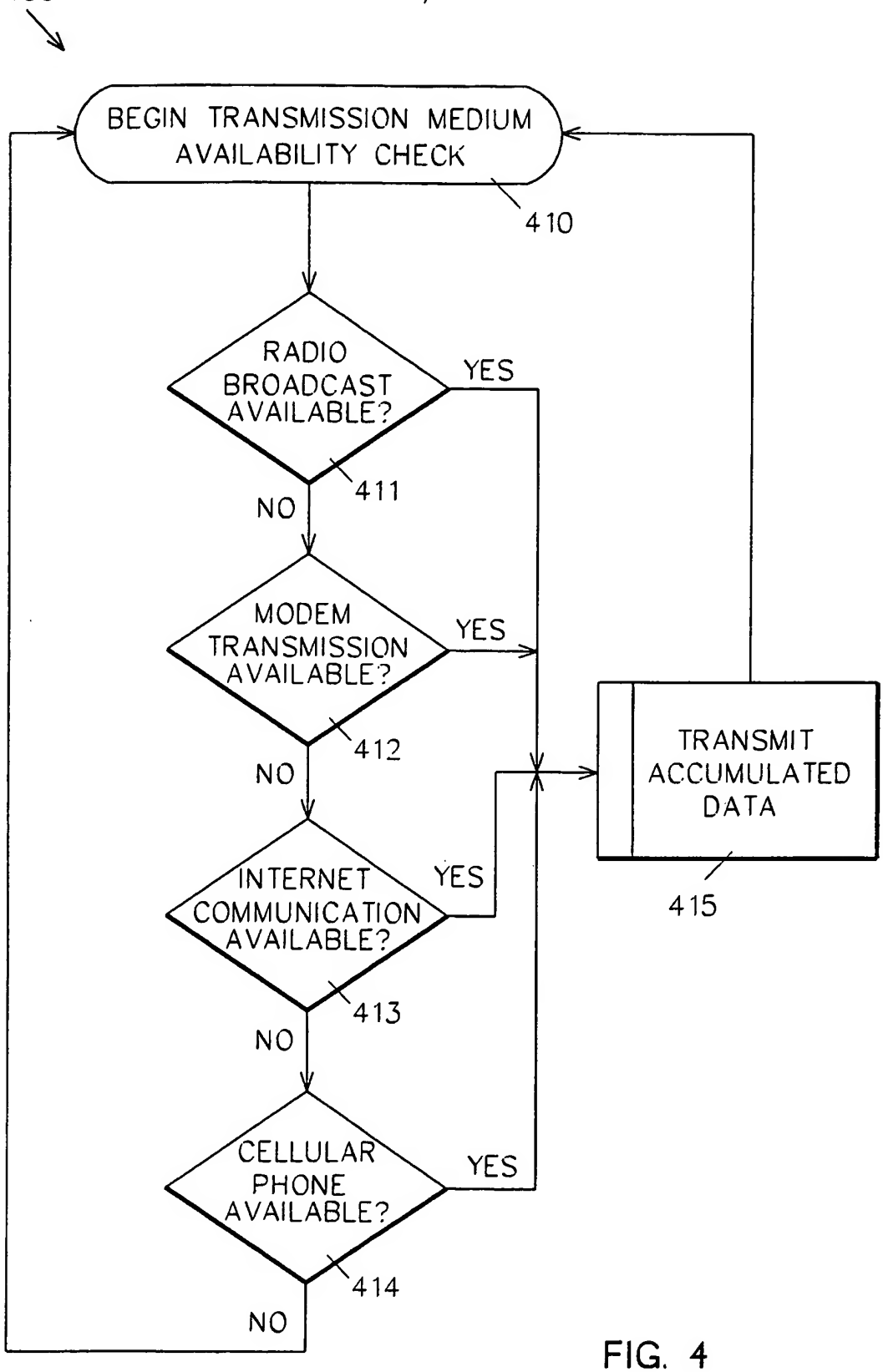
400
BEGIN TRANSMISSION MEDIUM AVAILABILITY CHECK
410
RADIO BROADCAST AVAILABLE?
YES
411
NO
MODEM TRANSMISSION AVAILABLE?
YES
412
NO
INTERNET COMMUNICATION AVAILABLE?
YES
413
NO
CELLULAR PHONE AVAILABLE?
YES
414
NO
TRANSMIT ACCUMULATED DATA
415

FIG. 4

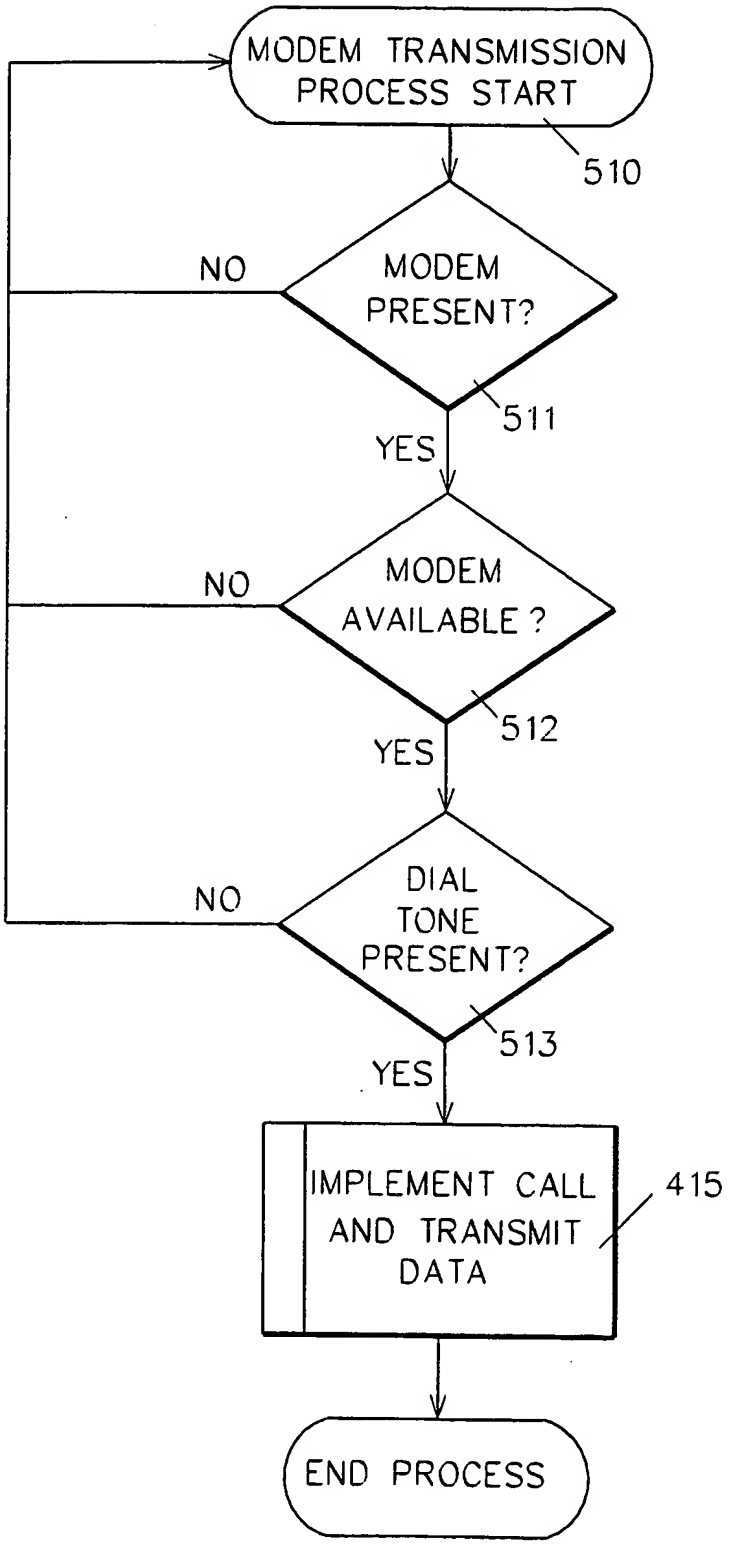
MODEM TRANSMISSION PROCESS START
510
MODEM PRESENT?
NO
511
YES
MODEM AVAILABLE ?
NO
512
YES
DIAL TONE PRESENT?
NO
513
YES
IMPLEMENT CALL AND TRANSMIT DATA
415
END PROCESS

FIG. 5

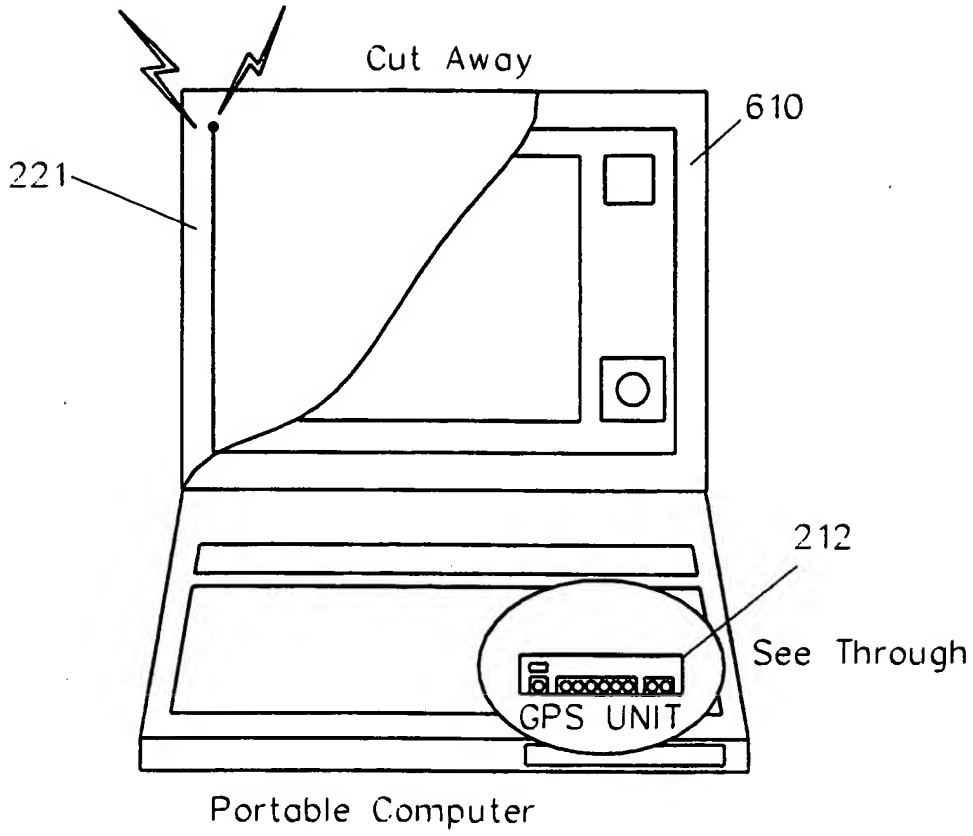

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/26889

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01S5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01S G08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 576 716 A (SADLER KERMIT M) 19 November 1996 (1996-11-19) * Summary of the Invention * column 1, line 51 - line 57 column 4, line 22 - line 25 claim 1 ---	1-23, 25-30
Y	US 5 748 084 A (ISIKOFF JEREMY M) 5 May 1998 (1998-05-05) column 1, line 27 - line 35 figure 3 abstract figure 5 column 2, line 21 - line 25 column 5, line 59 - line 16 * Summary of the Invention * --- -/--	1-6,9-19

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 April 2000	09/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ó Donnabháin, C

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INTERNATIONAL SEARCH REPORT

Inte...ational Application No
PCT/US 99/26889

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 731 785 A (LEMELSON JEROME H ET AL) 24 March 1998 (1998-03-24) abstract column 3, line 17 - line 30	7,8, 20-23, 25-30
P,A	US 5 936 526 A (KLEIN DEAN A) 10 August 1999 (1999-08-10) abstract * Description of the Structure of Another Embodiment of the Invention *	1-30
A	GB 2 304 250 A (NAT VULCAN SAFETY PRODUCTS LTD) 12 March 1997 (1997-03-12) abstract page 5, line 8 - line 10 page 4, line 8 - line 27	1-30

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte...ational Application No
PCT/US 99/26889

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5576716 A	19-11-1996	NONE	
US 5748084 A	05-05-1998	NONE	
US 5731785 A	24-03-1998	NONE	
US 5936526 A	10-08-1999	NONE	
GB 2304250 A	12-03-1997	NONE	